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ANNOSA ROOT ROT STUMP TREATMENT

a pilot project

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ANNOSA ROOT ROT STUMP TREATMENT: A PILOT PROJECT

By

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SUMMARY

Borax, sodium nitrite, *Peniophora gigantea*, and summer thinning were compared for effectiveness in prevention of annosa root rot in thinned loblolly, slash, and white pine plantations. Overall, borax provided the most effective protection against both stump surface colonization and residual tree infection and mortality.

[1]The authors are on the staff of the Forest Service's Southeastern Area, State and Private Forestry, with the exception of Mr. Weiss. He was a staff pathologist at the Area's Atlanta, Georgia, office at the time this publication was prepared; he is now Field Representative at the Northeastern Area's office at Portsmouth, N.H. Messrs. Peacher and Knighten are biological technicians stationed at Alexandria, Louisiana, and Asheville, North Carolina, respectively. Mr. Affeltranger is a plant pathologist, Alexandria, Louisiana.

Borax sprinkled on stumps helps prevent the spread of annosus root rot to healthy trees.

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A water solution containing the fungus *Peniophora gigantea* demonstrated potential for biological control of annosa root rot.

INTRODUCTION

Scope of Problem

Annosa root rot, caused by *Fomitopsis annosa* (Fr.) Karst. (formerly *Fomes annosus*), is a disease of conifers in many parts of the world. The disease has been found most frequently in association with stand thinnings. It first became of concern in the Southern United States in the late 1950's, after thinning of pine plantations became widespread. To date, annosa root rot has not been a serious problem in the South except in a limited number of local areas where site conditions have been particularly favorable to spread of the disease.

The surface of stumps exposed during thinnings are the main point of entry for *F. annosa*. Airborne spores of the fungus can travel long distances, land on the surface of stumps, germinate, and produce mycelium which invades the stump. Once established in the stump, the fungus can invade the stump roots and then spread to roots of adjacent living trees by means of root contacts. Factors that have been associated with the establishment and spread of the disease include frequency of thinning, season of thinning, competing organisms, soil texture and drainage, and fire.

The most promising measures for control of annosa root rot have been those designed to prevent establishment of *F. annosa* in stumps. These measures include application of chemical and biological agents to stump surfaces, and limitation of thinning to summer months, when conditions are less favorable for establishment of the fungus in the stumps.

Earlier Studies

Various chemical stump treatments have been tested. Among these have been creosote, urea, various borate compounds, and sodium nitrite. Creosote was the first material extensively tested and reported effective in preventing stump infection (Rishbeth 1952). The use of creosote was later discouraged because it preserves the stump and excludes harmless saprophytes that can aid in preventing *F. annosa* colonization. Berry and Bretz (1964), in a shortleaf pine plantation in Missouri, found that borate compounds, ammate, and ammonium fluoride, provided 85 percent or greater stump protection, whereas creosote offered 70 percent or less protection. Driver (1963a and 1963b), in Georgia slash pine plantations, found that borate compounds prevented stump infections more effectively than did creosote. Driver reported that dry borax provided good protection and discussed its advantages. Weidensaul and Plaugher (1966) found, in a mixed red and pitch pine plantation in Virginia, that creosote, urea, and borate compounds were equally effective in providing stump protection. These workers did not recommend creosote, however, mainly because it prevented stump deterioration. Rishbeth (1967) reported that sodium nitrite has been recommended for general use in Forestry Commission plantations in England, with care taken to allow for the material's toxicity. Artman and his co-workers (1969) found in loblolly plantations in Virginia that urea and dry, granular borax were equally effective in preventing infection of stumps. Hodges and his co-workers (1970) found in a slash pine plantation in South Carolina that borax protected stumps effectively against infection.

The most promising biological agent, of those tested, was a naturally occurring saprophytic fungus, *Peniophora gigantea* (Fr.) Massee. Rishbeth (1963) reported that stump inoculation with *P. gigantea* in Scotch pine and Corsican pine plantations in Great Britain, could be given serious consideration as an alternative to chemicals for protection against *F. annosa*. Boyce (1963) inoculated pine discs both with *F. annosa* and a *Peniophora* sp., probably *P. gigantea*, and found that *Peniophora* competed vigorously with *F. annosa*. Kuhlman and Hendrix (1964), in isolating organisms from stumps in a shortleaf pine stand in North Carolina, found that *P. gigantea* and *Trichoderma viride* both occurred often enough to be considered factors that limit stump colonization by *F. annosa*. *P. gigantea* replaced *F. annosa* in stumps with more than twice the effectiveness of *T. viride*. Hodges and his co-workers (1970), in a South Carolina slash pine plantation, reported that *P. gigantea* competed effectively with *F. annosa; Trichoderma* spp. were less effective. These workers also reported that *P. gigantea* could replace *F. annosa* in roots in which the latter fungus was already established.

Summer thinning has been suggested as one method for reducing the risk for *F. annosa* infec-

tion. Boyce (1963) found fewer airborne spores of *F. annosa* in two slash pine plantations in Georgia during June, July, and August than at other times of the year. He suggested initiating thinning tests to determine the amount of stump infection in various seasons. Driver and Ginns (1964) found that mean air temperatures above 70° F (21.1° C) limited the ability of *F. annosa* to establish infection centers in thinned slash pine plantations. Work by Ross (1968) in loblolly pine in Georgia indicates that the period of susceptibility of stumps to infection is short, and that stumps cut during the summer (when the likelihood of infection is low) are not likely to be infected in the fall. Ross (1968) reported on incidences of natural stump infection in a thinned slash plantation in south Georgia for 12 consecutive months. No natural infection occurred from April through August. Natural infection increased from about 3 percent in September to about 80 percent in December, declining to about 10 percent in January and 1 percent in March. Results of an extensive study by Ross (1973) of seasonal availability of *F. annosa* spores, effects of seasonal thinning, and other factors on development of *F. annosa*, suggest that pine plantations below 34° N latitude in the Southeast can be thinned from April through August with a low probability of stump infection. The risk of stump infection during the summer months is higher above this latitude.

Southwide Pilot Project

In 1969, the Southeastern Area's Forest Insect and Disease Management staff began a Southwide pilot project to compare the effectiveness of four promising treatments to prevent annosa root rot in thinned southern pine plantations (Phelps *et al.*, 1970). The project was carried out in cooperation with State forestry agencies, private landowners, and the Southeastern Forest Experiment Station. The results of the project are presented in this report.

Fruiting structure of the type shown at the base of the trunk is a typical symptom of infection by *F. annosa*.

MATERIALS AND METHODS

Plantations Selected

We selected 11 pine plantations in eight Southern States for the project (table 1; figure 1). The plantations ranged in age from 15 to 30 years and had not been previously thinned. All of the plantations are on sites rated as medium or high hazard to *F. annosa,* based on the soil texture, drainage, and cultural history of each. Of the 11 plantations, 6 are loblolly pine, 3 slash pine, and 2 white pine.

As a part of the project, we thinned the plantation in the manner and to the density prescribed by the landowner. The manner of thinning was by selection, by row, or by a combination of these two methods (table 2). We applied four treatments and a control in conjunction with the thinning. Each treatment or control was applied to four 1/5-acre (.08 ha), square plots; two of these were artificially inoculated and two were naturally inoculated with *F. annosa* spores. A 15-foot (4.6 m) border strip surrounding each plot was thinned and treated the same way as the plot.

Treatments

1. Borax. — Thinning was carried out during November, December, or January. We sprinkled a light covering of dry granular borax on the stump surface immediately after each tree was felled. We applied the borax from salt shaker-like containers made from 9 inch-diameter aerial film cans. The lid of each can had about 20 holes punched by an 8-penny nail.

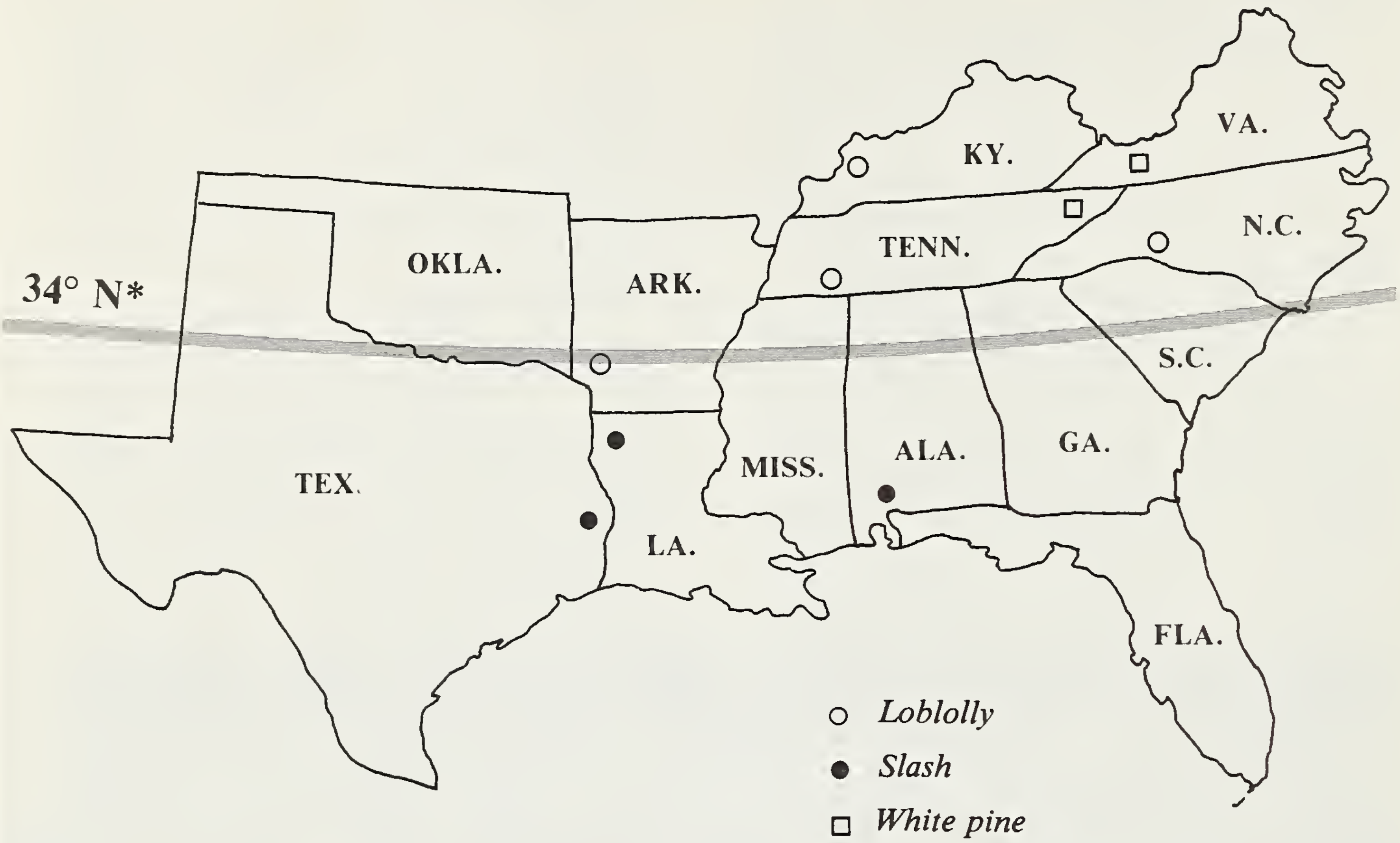
2. Sodium Nitrite. — Thinning was carried out during November, December, or January. We sprayed a 10 percent aqueous solution of sodium nitrite on the surface immediately after each tree was felled. We applied the solution to the point of runoff with a 2-gallon (7.6 l), garden-type, pressure sprayer.

3. Peniophora gigantea. — Thinning was carried out during November, December, or January. We sprayed conidial suspension of the fungus, *P. gigantea* (Fr.) Massee, on the stump surface immediately after each tree was felled. The suspension

Table 1. — Tree species, location, elevation, age, soil texture, and site history of plantations used in annosa root rot stump treatment pilot project.

Species	Location			Elevation (feet)	Age in 1969	Soil texture	Site history
	Nearest city	Latitude					
Loblolly	Franklin, Va.	36°	35'	35	22	Sandy loam (high water table)	Home site
Loblolly	West Point, Va.	37°	25'	25	15	Sandy loam	Old field
Loblolly	Hopkinsville, Ky.	37°	10'	540	20	Silt loam	Old field
Loblolly	Shelby, N. C.	35°	15'	845	18	Clay loam	Home site
Loblolly	Lexington, Tenn.	35°	30'	350	18	Sandy	Old field
Loblolly	Mineral Springs, Ark.	33°	30'	500	16	Sandy	Old field
Slash	Jasper, Tex.	30°	30'	240	20	Sandy loam	Old field
Slash	Jamestown, La.	32°	00'	250	20	Sandy	Old field
White pine	Wytheville, Va.	36°	40'	3,750	30	Silt loam	Forest
White pine	Del Rio, Tenn.	35°	45'	4,300	17	Silt loam	Homesite and apple orchard

Figure 1. — Location of plantations used in annosa root rot stump treatment pilot project



*Locations south of 34° N latitude may be subject to fewer problems from *F. annosa* if trees are thinned in the summer.

was prepared daily in the field with distilled water and four isolates of *P. gigantea*. We used a 2-gallon (7.6 l), garden-type, pressure sprayer.

4. Summer thinning. — Thinning was carried out during July or August. None of the treatments described above were used.

5. Control. — Thinning was carried out during November, December, or January. None of the treatments described above were used.

Inoculation and Sampling of *F. annosa*

Immediately after treatment, the stumps on two of the four plots in each treatment were artificially inoculated with *F. annosa*. We used a conidial suspension prepared daily in the field with distilled water and four to five isolates of the fungus. The minimum concentration of conidia used was 1.0 X 10^6 per milliliter. We applied inoculum to the point of runoff with a 2-gallon (7.6 l), garden-type pressure sprayer.

We determined the availability of airborne spores of *F. annosa* during each thinning by exposing spore traps during the early morning hours. Traps consisted of pine discs, about ⅜-inch (9.5 mm) thick, in plastic petri plates. Fifteen plates were initially exposed throughout each stand. We collected five plates at each 2-hour interval for 6 hours. The plates were stored in the laboratory for 1 to 2 weeks and then examined under a stereoscopic microscope for the *Oedocephalum* stage of *F. annosa*.

Temperature and Humidity

Maximum and minimum air temperatures were recorded over each 24-hour period during treatment. Humidity was recorded twice each day, once in the morning and once in the afternoon.

Evaluation Intervals

Approximately 5 months after treatment, we sampled selected stumps to determine the effectiveness of each treatment in preventing *F. annosa* colonization. Ten stumps were selected at random from within the 15-foot (4.6 m) boundary strip surrounding each 1/5-acre (.08 ha) plot. We cut a 2- to 3-inch (5 to 7.6 cm) disc from each of the selected stumps and immediately placed each disc in a polyethylene bag, which we then tied and labeled with the specific plot and treatment. Special care was taken to keep the discs from overheating during field storage and transportation to the laboratory. At the laboratory, we put a moistened paper towel in each paper bag, resealed the bag, and incubated the discs at room temperature for 10 to 15 days. All discs were then examined under a microscope for evidence of colonization by *F. annosa*. The presence of *Oedocephalum* conidiophores in any amount was considered positive evidence of successful colonization.

At intervals of 1 to 2 years from 1969 through 1977, we examined the plots to determine the effectiveness of the treatments in preventing residual tree infection and mortality. At each examination, we checked the trees in each plot for sporophores of *F. annosa*. Living trees with sporophores were considered to be infected by *F. annosa*, and dead trees with sporophores were considered to have been killed by *F. annosa*. Litter removed from around the root collar to find sporophores was replaced after each examination. This was done because sporophore formation is frequently dependent on the presence of litter.

Table 2. — Percentage of stumps colonized by F. annosa *5 months after treatment.*[1]

Treatment	Loblolly	Slash	White Pine
		percent	
Artificially inoculated			
1. Borax	1	0	0
2. Sodium nitrite	20	0	5
3. *Peniophora*	24	0	13
4. Summer thinning	41	3	55
5. Control	76	13	18
Naturally inoculated			
1. Borax	0	0	0
2. Sodium nitrite	6	3	3
3. *Peniophora*	11	0	5
4. Summer thinning	3	0	45
5. Control	29	10	3

[1]See Appendixes B and C for data on individual plantations.

RESULTS

In loblolly plantations, stump surface colonization (table 2), and subsequent residual tree infection and mortality (table 3 and Appendix E) were least on borax plots.

In slash plantations, stump surface colonization was approximately the same for all treatments (table 2). Residual tree infection and mortality were least on artificially inoculated borax plots (table 3 and Appendix F). Data on residual tree infection and mortality could be collected from only two of the original slash plantations. Wind destroyed one slash plantation soon after treatment.

In white pine plantations, stump surface colonization was least on borax plots, and highest on plots with summer thinning (table 2). Residual tree infection and mortality was low on borax, sodium nitrite, and *Peniophora* plots and high on plots with summer thinning (table 3 and Appendix G). Residual tree infection and mortality occurred in only one of the two white pine plantations.

During winter treatments, airborne *F. annosa* spores were trapped in all plantations except the loblolly plantation in Tennessee. The lack of spores in that plantation may have been caused by heavy rain and freezing temperatures which preceded treatment. During summer thinnings, no airborne spores were trapped in any of the plantations except in the loblolly plantation in Arkansas.

Maximum and minimum temperatures recorded during treatment are presented in Appendix H. Humidity readings also are presented in Appendix H.

The amount of mortality caused by agents other than *F. annosa* is shown in Appendixes I., J., and K. Listed in these tables are all dead trees on which *F. annosa* sporophores were not found. The amount of this mortality did not appear to be related to the method of treatment. Mortality of loblolly pine attributed to causes other than *F. annosa* was highest during the early years of the project (Appendix M).

A yearly breakdown of the mortality caused by *F. annosa* in loblolly pine plantations included in the pilot project is shown in Appendix L.

Table 3. — Trees killed and infected by F. annosa *from 1969 through 1977.*

Treatment	Loblolly			Slash			White Pine[2]		
	Residual trees[1]	Killed	Killed and green infected	Residual trees	Killed	Killed and green infected	Residual trees	Killed	Killed and green infected
	Number	*– percent – – –*		*Number*	*– – percent – –*		*Number*	*– – percent – – –*	
Artificially inoculated									
1. Borax	813	1.0	2.3	268	0.4	0.4	100	3.0	3.0
2. Sodium nitrite	859	4.7	7.0	224	1.3	8.5	84	0	2.4
3. *Peniophora*	790	6.2	8.0	275	1.5	2.9	107	0.9	2.8
4. Summer thinning	804	5.5	9.6	210	1.4	4.3	65	4.6	9.2
5. Control	889	5.6	10.3	269	6.7	20.0	96	1.0	2.0
Naturally inoculated									
1. Borax	905	2.2	2.5	225	1.8	1.8	77	0	0
2. Sodium nitrite	854	5.0	8.4	304	1.3	1.3	113	0	0
3. *Peniophora*	890	3.4	5.6	230	0.9	0.9	86	1.2	1.2
4. Summer thinning	889	3.7	4.6	250	1.6	1.6	118	4.2	4.2
5. Control	929	6.7	12.0	279	1.1	2.9	122	0.8	0.8

[1]Trees left after thinning.

[2]Only one of two plantations is shown. No trees were infected by *F. annosa* in the plantation not shown.

DISCUSSION

Borax provided the most effective and consistent protection against stump surface colonization, residual tree infection and mortality.

Summer thinning was comparatively ineffective, probably because the plantations used in the pilot project were in northerly locations where summer temperatures are usually not high enough to reduce the risk of stump colonization. Ross (1973) suggested that pine plantations below 34° N latitude in the Southeast can be thinned from April to August with a low probability of stump infection. All of the plantations used in the pilot project are above or only slightly south of 34° N latitude (table 1). Ross found that the risk of stump infection in the late spring and summer was minimal after mean air temperatures reached 70° F (21° C) and maximum temperatures reached 90° F (32° C), 6 inches (15 cm) above the ground. Maximum temperatures of 90° F were reached in some loblolly plantations on days when summer thinning was done (Appendix H). Mean temperatures were not recorded. Maximum temperatures reached 90° F and minimum temperatures were 70° F or more in slash pine plantations on days when summer thinning was done (Appendix H). While results of the pilot project indicate that summer thinning is not effective at northerly locations in the South, the use of summer thinning at southerly locations should still be considered.

Also, in spite of the results of this pilot project, *Peniophora* should be considered for use in stands previously thinned and already infected by *F. annosa*. Kuhlman and his co-workers (1976) point out the potential drawbacks of using stump protectants such as borax in infected stands, and suggest summer thinning or *Peniophora* be used in place of borax in such stands. In infected stands, stump protectants such as borax will not prevent growth of *F. annosa* through root systems, and may even aggravate the problem by preventing colonization by natural competitors of *F. annosa*.

This test differed from most previous tests in that the effectiveness of the treatments was determined not only by the amount of stump colonization, but also by the amount of residual tree infection and mortality. A comparison of tables 2 and 3 indicates some value in recording residual tree infection and mortality. For example, in the slash plantations, all treatments might have been considered equally effective if the amount of stump colonization alone had been considered.

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APPENDIXES

Appendix A: Ownership of Plantations Used in Pilot Project

Species	Location	Ownership
Loblolly	Franklin, Va.	Union Camp Corporation
	West Point, Va.	Chesapeake Corporation of Virginia
	Kentucky	State of Kentucky
	North Carolina	Catawba Timber Company
	Tennessee	Tennessee River Pulp and Paper Company
	Arkansas	International Paper Company
Slash	Texas	International Paper Company
	Louisiana	Bodcaw Company
	Alabama[1]	Scott Paper Company
White pine	Virginia	Jefferson National Forest
	Tennessee	Cherokee National Forest

[1] Plantation destroyed by wind, and abandoned.

Appendix B: Dates and Types of Thinnings in Plantations Used in Annosa Root Rot Stump Treatment Pilot Project.

Species	Location	Winter thinning	Summer thinning	Spacing before thinning	Type of thinning
		———*dates*	———	———*feet*———	
Loblolly	Franklin, Va.	12/8 - 11/69	8/13 - 31/70	6 x 8	every third row and selective
	West Point, Va.	12/2 - 5/69	8/11 - 12/70	6 x 8	every third row
	Kentucky	10/14 - 11/3/69	7/27 - 31/70	6 x 8	every other row
	North Carolina	11/4-14/69; 1/3/70	7/22 - 31/70	6 x 8	every third row
	Tennessee	11/19- 26/69	7/21/70	6 x 8	every third row
	Arkansas	2/3 - 5/69	7/7 - 8/70	6 x 10	every other row
Slash	Texas	12/15 - 16/69	8/11 - 12/70	6 x 8	selective
	Louisiana	12/16-24/69; 1/3/70	8/4 - 5/70	6 x 7	selective
White pine	Virginia	11/18 - 21/69	7/14/70	6 x 8	row and selective
	Tennessee	12/2 - 5/69	8/4/70	6 x 8	every third row

Appendix C: Percentage of Sampled Stumps Colonized by *F. annosa* 5 Months After Treatment, by Species, Location, and Treatment Method (Artificially Inoculated)

Species	Location	Treatment: Borax	Sodium nitrite	*Peniophora*	Summer thinning	Control
Loblolly	Franklin, Va.	0	20	60	70	80
	West Point, Va.	0	15	45	90	75
	Kentucky	0	45	0	70	100
	North Carolina	5	10	35	0	85
	Tennessee	0	30	5	10	100
	Arkansas	0	0	0	5	15
Average Percent		1	20	24	41	76
Slash	Texas	0	0	0	0	5
	Louisiana	0	0	0	5	20
Average Percent		0	0	0	3	13
White pine	Virginia	0	10	15	85	30
	Tennessee	0	0	10	25	5
Average Percent		0	5	13	55	18

Appendix D: Percentage of Sampled Stumps Colonized by *F. annosa* 5 Months After Treatment, by Species, Location, and Treatment (Naturally Inoculated)

Species	Location	Treatment: Borax	Sodium nitrite	*Peniophora*	Summer thinning	Control
Loblolly	Franklin, Va.	0	5	25	15	35
	West Point, Va.	0	0	5	0	55
	Kentucky	0	10	10	5	20
	North Carolina	0	20	25	0	40
	Tennessee	0	0	0	0	15
	Arkansas	0	0	0	0	5
Average Percent		0	6	11	3	29
Slash	Texas	0	0	0	0	5
	Louisiana	0	5	0	0	20
Average Percent		0	3	0	0	10
White pine	Virginia	0	5	0	70	0
	Tennessee	0	0	10	20	5
Average Percent		0	3	5	45	3

Appendix E: Residual Loblolly Pine Killed and Infected by *F. annosa* from 1969 through 1977, by Location, Inoculation Method, and Treatment Method[1]

Treatment	Franklin, Va.			West Point, Va.			Kentucky			North Carolina		
	Residual trees	Killed	Killed and green infected	Residual trees	Killed	Killed and green infected	Residual Trees	Killed	Killed and green infected	Residual trees	Killed	Killed and green infected
	Number	*- - - Percent - - -*		*Number*	*- - - Percent - - -*		*Number*	*- - - Percent - - -*		*Number*	*- - - Percent - - -*	
Artificially inoculated												
1. Borax	167	1.2	4.2	156	0	1.3	52	0	0	129	2.3	3.1
2. Sodium nitrite	173	2.3	7.5	193	6.2	8.8	62	1.6	3.2	180	2.7	3.3
3. *Peniophora*	134	6.0	8.2	143	4.2	7.0	42	0	0	158	13.9	13.9
4. Summer thinning	147	2.7	6.8	63	12.3	18.4	101	4.0	5.0	189	6.3	6.9
5. Control	138	2.2	3.6	187	7.5	15.0	73	2.7	4.1	144	7.6	9.7
Naturally inoculated												
1. Borax	160	1.3	1.9	201	1.0	1.5	67	0	0	154	9.0	9.7
2. Sodium nitrite	164	1.2	4.3	178	4.5	10.1	69	0	2.9	152	16.4	22.4
3. *Peniophora*	177	4.5	8.5	169	4.1	7.1	90	1.1	2.2	151	8.6	8.6
4. Summer thinning	231	1.7	3.9	113	2.7	5.3	88	0	0	154,	16.2	16.2
5. Control	189	5.8	12.7	175	13.7	22.3	101	2.0	8.9	156	8.3	9.6

Treatment	Tennessee			Arkansas			Total		
	Residual trees	Killed	Killed and green infected	Residual trees	Killed	Killed and green infected	Residual trees	Killed	Killed and green infected
	Number	*- - - Percent - - -*		*Number*	*- - - Percent - - -*		*Number*	*- - - Percent - - - -*	
Artificially inoculated									
1. Borax	215	1.9	3.3	94	0	0	813	1.0	2.3
2. Sodium nitrite	160	11.2	16.2	91	0	0	859	4.7	7.0
3. *Peniophora*	222	5.9	6.8	91	0	5.5	790	6.2	8.0
4. Summer thinning	204	2.0	2.5	100	0	17.0	804	5.5	9.6
5. Control	248	15.3	23.8	99	0	1.0	889	5.6	10.3
Naturally inoculated									
1. Borax	215	0.9	0.9	108	0	0	905	2.2	2.5
2. Sodium nitrite	182	4.4	6.0	109	0	0	854	5.0	8.4
3. *Peniophora*	193	0.5	2.0	110	0	1.8	890	3.4	5.6
4. Summer thinning	178	0	0	125	0.8	0.8	889	3.7	4.6
5. Control	217	5.5	10.6	91	1.0	3.0	929	6.7	12.0

[1] Residual trees are those trees left after thinning.

Appendix F: Residual Slash Pine Killed and Infected by *F. annosa* from 1969 through 1977, by Location, Inoculation Method, and Treatment Method.

Treatment	Texas			Louisiana			Total		
	Residual trees	Killed	Killed and green infected	Residual trees	Killed	Killed and green infected	Residual trees	Killed	Killed and green infected
	Number	– *Percent*		*Number*	– – *Percent* – –		*Number*	– – – *Percent*	
Artificially inoculated									
1. Borax	156	0	0	112	0.9	0.9	268	0.4	0.4
2. Sodium nitrite	144	2.0	11.8	80	0	2.5	224	1.3	8.5
3. *Peniophora*	168	0.6	1.2	107	2.8	5.6	275	1.5	2.9
4. Summer thinning	117	0	4.3	93	3.2	4.3	210	1.4	4.3
5. Control	160	8.7	30.0	109	3.7	6.4	269	6.7	20.0
Naturally inoculated									
1. Borax	116	0	0	109	3.7	3.7	225	1.8	1.8
2. Sodium nitrite	179	0	0	125	3.2	3.2	304	1.3	1.3
3. *Peniophora*	131	0	0	99	2.0	2.0	230	0.9	0.9
4. Summer thinning	167	0	0	83	4.8	4.8	250	1.6	1.6
5. Control	171	0	1.8	108	2.8	4.6	279	1.1	2.9

Appendix G: Residual White Pine Killed and Infected by *F. annosa*, by Location, Inoculation Method, and Treatment Method.

Treatment	Virginia			Tennessee		
	Residual trees [1]	Killed	Killed and green infected	Residual trees	Killed	Killed and green infected
	Number	– – – *Percent* – – –		*Number*	– – – *Percent* – – –	
Artificially inoculated						
1. Borax	100	3.0	3.0			
2. Sodium nitrite	84	0	2.4			
3. *Peniophora*	107	0.9	2.8	No trees were infected by *F. annosa*		
4. Summer thinning	65	4.6	9.2			
5. Control	96	1.0	2.0			
Naturally inoculated						
1. Borax	77	0	0			
2. Sodium nitrite	113	0	0			
3. *Peniophora*	86	1.2	1.2	No trees were infected by *F. annosa*		
4. Summer thinning	118	4.2	4.2			
5. Control	122	0.8	0.8			

[1] Trees left after thinning

Appendix H: Air Temperature and Humidity Readings During Treatment

Species	Location	Date	Temperature Low	Temperature High	Humidity AM	Humidity PM
			Degrees F		Percent	
Loblolly	Franklin, Va.	12-8-69 (winter thinning)[1]	––	49	99	100
		12-9-69[2]	43	48	100	100
		12-10-63[3]	41	63	100	100
		12-11-69	47	54	81	78
		8-13-70 (summer thinning)	68	93	63	55
Loblolly	West Point, Va.	12-2-69 (winter thinning)	––	40	––	40
		12-3-69	24	53	53	48
		12-4-69	26	36	51	50
		12-5-69	20	––	60	––
		8-11-70 (summer thinning)	71	85	95	69
		8-12-70	62	90	97	53
Loblolly	Kentucky	10-14-69 (winter thinning)	29	51	79	68
		10-15-69	33	64	56	56
		10-16-69	34	60	––	60
		10-17-69	28	57	47	44
		10-18-69	32	65	41	35
		10-19-69	40	77	53	45
		10-20-69	––	––	94	––
		7-28-70 (summer thinning)	––	91	65	––
Loblolly	North Carolina	11-4-69 (winter thinning)	35	62	60	––
		11-5-69	29	50	56	––
		11-6-69	30	64	95	33
		11-7-69	38	69	99	42
		11-12-69	29	66	81	50
		11-13-69	30	53	48	59
		11-14-69	––	51	53	––
		7-21-70 (summer thinning)[3]	––	82	100	100
		7-22-70	61	66	100	100
		7-23-70	64	87	100	100
		7-24-70	––	78 (11 AM)	––	––
Loblolly	Tennessee	11-19-69 (winter thinning)	23	53	––	––
		11-20-69	20	60	––	––
		11-21-69	––	64	––	––
		11-24-69	50	62	––	––
		7-21-70 (summer thinning)	64	68	––	––
Loblolly	Arkansas	2-3-70 (winter thinning)	17	41	––	––
		2-4-70	18	48	––	––
		2-5-70	31	58	––	––
		7-7-70 (summer thinning)	73	92	––	––
		7-8-70	73	90+	––	––

[1] Rain, 12-7-69

[2] Misty

[3] Rain

(continued)

Appendix H — Continued

Species	Location	Date	Temperature Low	Temperature High	Humidity AM	Humidity PM
			Degrees F		*Percent*	
Slash	Texas	12-15-69 (winter thinning)	46	58	--	--
		12-16-69	—	52	--	--
		8-11-70 (summer thinning)	72	86	--	--
		8-12-70	70+	90+	--	--
Slash	Louisiana	12-16-69 (winter thinning)	36	54	--	--
		12-17-69	47	62	--	--
		12-18-69	53	64	--	--
		12-19-69	30	52	--	--
		1-3-70	16	--	--	--
		8-4-70 (summer thinning)	73	84	--	--
		8-5-70	70	90+	--	--
White Pine	Virginia	Winter thinning: Cold, with rain and sleet; temperature and humidity data lost.				
		Summer thinning: Temperature and humidity data lost.				
White Pine	Tennessee	12-2-69 (winter thinning)	30	36	54	--
		12-3-69	30	38	--	56
		12-4-69	20	26	--	80
		12-5-69	12	36	74	--
		8-4-70 (summer thinning)[3]	--	68	100	100

[1]Rain, 12-7-69 [2]Misty [3]Rain

Appendix I: Percentage of Residual Loblolly Pine Killed from 1969 through 1977 by Causes Other Than *F. annosa*[1]

Treatment	Franklin Va.	West Point Va.	Kentucky	North Carolina	Tennessee	Arkansas	Total
1. Borax:							
Artificially inoculated	7.8	7.1	9.6	17.1	9.8	2.1	9.1
Naturally inoculated	5.6	10.4	1.5	15.6	13.5	3.7	9.8
2. Sodium nitrite:							
Artificially inoculated	2.9	5.2	1.6	16.7	6.9	2.2	6.8
Naturally inoculated	4.3	7.3	5.8	7.2	14.8	0.9	10.7
3. *Peniophora:*							
Artificially inoculated	6.0	4.9	9.5	13.9	13.5	0	8.7
Naturally inoculated	4.0	5.9	6.7	10.6	16.0	3.6	8.0
4. Summer thinning:							
Artificially inoculated	12.9	1.2	3.0	21.2	13.7	5.0	12.3
Naturally inoculated	12.1	10.6	4.5	13.0	19.1	6.4	12.6
5. Control:							
Artificially inoculated	5.8	5.3	8.2	9.0	8.0	2.0	7.1
Naturally inoculated	5.8	6.3	3.0	7.7	11.5	0	7.1

[1]This table lists all dead trees on which *F. annosa* sporophores were not found.

Appendix J: Percentage of Residual Slash Pine Killed from 1969 through 1977 by Causes Other than *F. annosa*[1]

Treatment	Texas	Louisiana	Total
1. Borax:			
Artificially inoculated	1.3	16.0	7.5
Naturally inoculated	0.9	10.0	5.3
2. Sodium nitrite:			
Artificially inoculated	0.7	8.8	3.6
Naturally inoculated	3.3	19.2	9.9
3. *Peniophora:*			
Artificially inoculated	1.8	10.3	5.0
Naturally inoculated	0.8	7.0	3.5
4. Summer thinning:			
Artificially inoculated	1.7	16.1	8.0
Naturally inoculated	5.4	20.5	10.4
5. Control:			
Artificially inoculated	0	11.0	4.5
Naturally inoculated	1.8	13.0	6.0

[1]This table lists all dead trees on which *F. annosa* sporophores were not found.

Appendix K: Percentage of Residual White Pine Killed from 1969 through 1977 by Causes Other Than *F. annosa*[1]

Treatment	Tennessee	Virginia	Total
1. Borax:			
Artificially inoculated	29.5	6.0	34.1
Naturally inoculated	8.7	5.2	7.4
2. Sodium nitrite:			
Artificially inoculated	13.2	14.3	13.7
Naturally inoculated	5.7	3.5	4.7
3. *Peniophora:*			
Artificially inoculated	18.9	2.8	11.4
Naturally inoculated	14.3	5.8	10.8
4. Summer thinning:			
Artificially inoculated	9.3	4.6	7.5
Naturally inoculated	11.1	7.6	9.2
5. Control:			
Artificially inoculated	17.9	14.6	16.5
Naturally inoculated	17.8	2.5	9.0

[1]This table lists all dead trees on which *F. annosa* sporophores were not found.

Appendix L: Loblolly Pine Killed by *F. annosa*, by Year of Pilot Project

Location	1971 - 72 and 1972 - 73	1973 - 74 and 1974 - 75	1975 - 76 and 1976 - 77
	----------------	Number	----------------
Franklin, Va.	9	17	15
West Point, Va.	30	49	26
Kentucky	3	6	2
North Carolina	74	52	10
Tennessee	21	29	50
Arkansas	1	1	0
Total	138	154	103

Appendix M: Loblolly Pine Killed by Causes Other Than *F. annosa*, by Year of Pilot Project[1]

Location	1971 - 72 and 1972 - 73	1973 - 74 and 1974 - 75	1975 - 76 and 1976 - 77
	----------------	Number	----------------
Franklin, Va.	29	65	30
West Point, Va.	37	53	24
Kentucky	6	22	10
North Carolina	127	63	24
Tennessee	120	53	83
Arkansas	10	9	9
Total	329	265	180

[1] This table lists all dead trees on which *F. annosa* sporophores were not found.

PESTICIDE PRECAUTIONARY STATEMENT

Pesticides used improperly can be injurious to man, animals, and plants. Follow the directions and heed all precautions on the labels.

Store pesticides in original containers under lock and key — out of the reach of children and animals — and away from food and feed.

Apply pesticides so that they do not endanger humans, livestock, crops, beneficial insects, fish, and wildlife. Do not apply pesticides when there is danger of drift, when honey bees or other pollinating insects are visiting plants, or in ways that may contaminate water or leave illegal residues.

Avoid prolonged inhalation of pesticide sprays or dusts; wear protective clothing and equipment if specified on the container.

If your hands become contaminated with a pesticide, do not eat or drink until you have washed. In case a pesticide is swallowed or gets in the eyes, follow the first-aid treatment given on the label, and get prompt medical attention. If a pesticide is spilled on your skin or clothing, remove clothing immediately and wash skin thoroughly.

Do not clean spray equipment or dump excess spray material near ponds, streams, or wells. Because it is difficult to remove all traces of herbicides from equipment, do not use the same equipment for insecticides or fungicides that you use for herbicides.

Dispose of empty pesticide containers promptly. Have them buried at a sanitary land-fill dump, or crush and bury them in a level, isolated place.

Some States have restrictions on the use of certain pesticides. Check your State and local regulations. Also, because registrations of pesticides are under constant review by the U.S. Environmental Protection Agency, consult your county agricultural agent or State extension specialist to be sure intended use is still registered. (Because *P. gigantea* is a naturally occurring organism in southern pine forests, cultures of the organism are not considered a pesticide under the Federal Insecticide, Fungicide, and Rodenticide Act, as amended; and therefore, this organism when used as an inoculum on freshly cut stumps does not require registration. Ref. E.P.A. ruling April 30, 1976.)

For additional information contact your State Forestry Organization
or
USDA Forest Service, Southeastern Area
1720 Peachtree Street, N.W.
Atlanta, Georgia 30309

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Use Pesticides Safely
FOLLOW THE LABEL